



Biomechanical analysis of landing after spiking in volleyball

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論 文 の 内 容 の 要 旨

1. Introduction

In volleyball, landing after spiking is likely the type of landing more prone to injuries because of the large ground reaction forces involved upon the impact with the floor. Therefore, the purposes of this study were to gain insights into the motions that affect landing posture by investigating the landing after spiking cross-court in the left front zone and to draw suggestions to improve techniques for safe landing.

2. Research problems

Problem 1 : Kinematic Study on the Spike-Landing Motion of Elite Male Volleyball Players During Official Games

The spiking characteristics of male elite volleyball players ascertained for the left front zone in this study indicated that the player timely used a compact and fast trunk twist with a small left lean that ended before contacting the ball in the double-legged landing, which may be why a straight body configuration was maintained and why the right leg did not elevate as in the case of the single-legged landing; this technique may increase the chances of a double-legged landing. A moderate backswing position of the trunk and a neutral alignment of shoulders and hips at the ball impact can be critical motions to be observed in evaluating this technique.

Problem 2 : Effects of Horizontal Jumping Direction on the Spike-Landing Motion of Elite Male Volleyball Players

Landings were mostly left-legged and the jumping direction largely differed. For spiking cross-court, an OUT-IN HJD was found more appropriate over an IN-OUT HJD because it favors the application of the aforesaid techniques. In the sole double-legged landing, a skilled player timely used fast short trunk twist that ended before contacting the ball, which may be the reason why balance was kept and the right leg did not elevate.

Problem 3 : The Effects of Jumping Distance on the Landing Mechanics after a Volleyball Spike

The body center of gravity horizontal and vertical velocities were increased in spiking with an increased jumping

distance compared with normal spiking, which caused several postural changes at the initial contact that eventually increased the peak ground reaction forces and mean loading rates. A raised trunk with extended hip and a slight knee flexion at the initial contact, followed by large ranges of motion in the knee and ankle before the heel strike, were critical elements of safer landings.

Problem 4 : The Effects of Ball Hit on the Landing Mechanics after Spiking in Volleyball

The results revealed that the landings under the “No Ball” condition produced significantly greater center of gravity horizontal and vertical velocities but smaller ground reaction peak forces and mean loading rates compared with the “Ball Hit” condition. Removing the ball hit in spikes may facilitate the execution of safer techniques of landing after spiking in volleyball.

3. Discussion and Conclusions

The airborne motions prior to landing and the body posture at the instant of floor contact were the kinematic aspects best related to the changes observed in the ground reaction forces during landing. A large trunk motion, particularly a left lean, was responded by large motion of the lower limbs that resulted in elevation of the right leg, thus left-legged landings. At the instant of floor contact, landing with a raised trunk produced smaller ground reaction forces indicating that this posture contributed to better utilize proper ranges of motion in the lower limb joints during the period of landing impact absorption.

A large range of motion in the knee from the floor contact to the heel strike decreased the vertical peak force, so landing with a soft knee joint is considered crucial for safety measures. The knee angle at the floor contact should be close to full extension to enable large flexion thereafter. A slight knee flexion at the floor contact may facilitate proper subsequent flexion until the heel strike and turn the landing soft in the knee. However, small range of motion after the heel strike is recommended to ensure more ability to generate extensor force to stop body descent motion, and a large maximal flexion of the knee should be avoided to prevent an increase in the ground reaction force moment arm around this joint and in the loading on the patellar tendon.

The (dorsiflexion) range of motion in the ankle from the floor contact to the heel strike reduced significantly the mean loading rate during landing. A trunk excessively leaned backward and a too much flexed hip at landing make for a sign of poor landing that will likely be flat-footed, so coaches are suggested to spot the trunk motion during spike and the hip angle at the floor contact, besides the ankle angle.

Proper landing techniques are not always possible to be applied after spiking and losing balance in the air. For these occasions, follow-up moves such as land-and-go, land-and-cross-step, and land-and-roll might decrease the body momentum during landing more effectively than an abrupt stop. Strengthening of the lower limbs muscles and specific multi jumps training for landing are also recommended.

審 査 の 結 果 の 要 旨

本論文は、一流男子バレーボール選手および大学選手のスパイク打突後の着地動作をバイオメカニクスのに分析し、左脚着地が多い原因、水平跳躍距離の衝撃力への影響などについて検討するとともに、得られた知見から障害発生の少ないスパイク動作や着地動作を明らかにし、そのトレーニング法に関する示唆を引き出そうとしたものである。

論文審査会では、1) 着地後に脚を屈曲して衝撃を緩衝する場合の許容できる膝屈曲の程度とその根拠、脚への負担が小さい着地動作の習得のためのトレーニング方法にはどのようなものが考えられるか、2) 空中での身体姿勢の調整を容易にするような踏切動作とはどのようなものか、角運動量は検討したか、3) 足、

膝、股関節への地面反力の影響を下肢関節トルクと関連付けて考えるとどのようになるか、4) 多くの選手が左脚で着地するので、得られた知見から実際の試合における安全な片脚着地のための技術はどのようなものか、5) 今後現場にどのように適用していくか、などの質問があった。

著者は、これらの質問のうち、現有のデータに基づいて回答できるものに関しては図や身振りを交えながら適切に回答し、データが不十分なものについては文献研究を引用して著者の見解を述べた。なお、角運動量や下肢関節トルクに関しては本研究の実験上の制約があり十分な検討ができなかったため、今後の課題としたい旨の説明があった。しかし、本研究はほとんど研究例の報告がない実際の試合における一流選手の着地動作を詳細に3次元分析し、多くの選手が左脚着地になるキネティクスのメカニズムを明らかにしたこと、水平跳躍距離が着地衝撃に及ぼす影響を実験的に明らかにしたこと、得られた知見から安全な着地のためのスパイク動作や空中動作（姿勢）に関する示唆を引き出し、トレーニング法についても言及していることなどが高く評価された。したがって、本論文は、体育科学の博士論文に相応しいと判断された。

平成25年2月6日、学位論文審査委員会において、審査委員全員出席のもと論文について説明を求め、関連事項について質疑応答を行った（学力の確認は免除）。その結果、審査委員全員が合格と判定した。

よって、著者は博士（体育科学）の学位を受けるに十分な資格を有するものと認める。